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Science

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Newfoundland and Labrador Region

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Science Advisory Report 2013/012

ASSESSMENT OF DIVISIONS 2G-3K (SHRIMP FISHING AREAS 4-6) NORTHERN SHRIMP

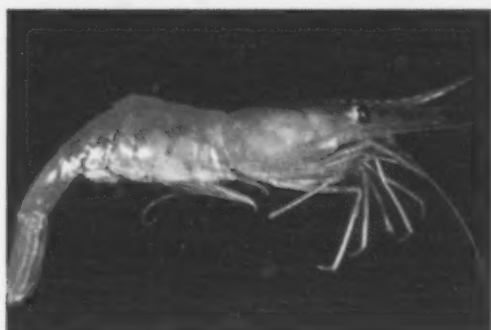


Photo: DFO Newfoundland and Labrador 2003

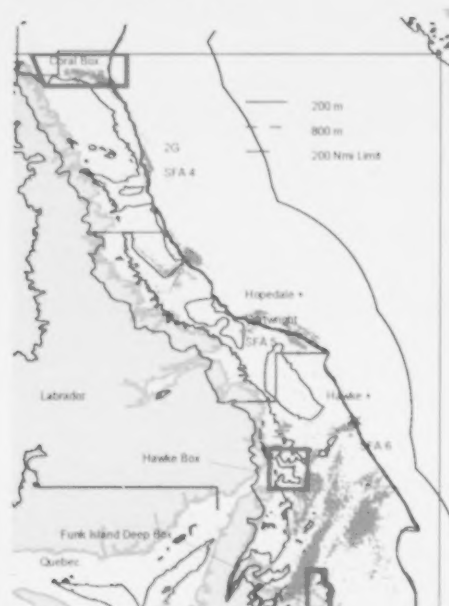


Figure 1. Map of Shrimp Fishing Areas (SFAs) including the Coral Box, Hawke Channel and Funk Island Deep closed areas. The red crosses identify large and small vessel fishing positions during 2012.

Context:

The bottom trawl fishery for Northern Shrimp (*Pandalus borealis*) off the coast of Labrador began in the mid-1970s, primarily in the Hopedale and Cartwright channels, Shrimp Fishing Area (SFA) 5, expanding north to SFA 4 and south to SFA 6 through the 1980s. The management year for SFAs 4-6 changed from a calendar year to April 1–March 31 in 2003. The current overall Total Allowable Catch (TAC) is 97,000 tonnes (t). The TACs were taken during most years.

DFO Fisheries Management requested science advice on the status of Northern Shrimp in SFAs 4, 5, and 6. This resource was last assessed during February 2011 and is normally assessed on a biennial basis with updates in the interim years.

A formal assessment of the resource was conducted during February 18–26, 2013. The assessment made use of fishery data from observer and logbook datasets when estimating catch rate indices. Bottom trawl surveys provided indices of recruitment, female spawning stock biomass (SSB), fishable biomass, and exploitation rate.

This report provides a summary of key results of the assessment, a narrative describing the fishery with an expanded discussion of resource status and outlook.

SUMMARY

- Shrimp (*Pandalus* sp.) and Capelin (*Mallotus villosus*) are key forage species in Northwest Atlantic Fisheries Organization (NAFO) Divisions (Div.) 2J3KL (SFAs 5, 6, and 7). Capelin abundance is at very low levels while some groundfish are increasing. Together this may increase predation pressure on shrimp.
- Resource status was updated based on a DFO fall multi-species research vessel (RV) bottom trawl survey series (1996-2012), which provided information on shrimp distribution, abundance, biomass, recruitment, and size in the Div. 2J portion of SFA 5 and Hawke Channel + Div. 3K (SFA 6). Trends in fishery performance were also inferred from fishery catch per unit effort (CPUE) and fishing patterns.
- The Northern Shrimp Research Foundation (NSRF) in partnership with Fisheries and Oceans Canada (DFO) conducted annual shrimp based research surveys in Div. 2G (SFA 4) during 2005-12.
- The resource decreased from a peak in 2006 to near 1996 levels in the south (SFA 6); remained near average on the mid-Labrador Shelf (SFA 5) and increased in the north (SFA 4).

SFA 6 (Hawke Channel and NAFO Division 3K)

- Catch decreased from a peak of 81,000 t in 2007/2008 to 46,000 t in 2009/2010; remaining near 60,000 t since. It is expected that the 2012/2013 TAC of 60,245 t will be taken.
- The large vessel CPUE increased between 1989 and 1997 and oscillated at a high level until 2006/2007, thereafter it declined until 2009/2010 but has since been increasing. The small vessel CPUE showed a similar pattern.
- Fishable biomass index increased from 310,000 t in 1997 to a peak of nearly 670,000 t in 2006 then declined steeply to 295,000 t in 2010, increased to 409,000 t in 2011 before returning to 316,000 t by 2012.
- The trend in female spawning stock biomass (SSB) index reflected the trend in the fishable biomass index decreasing to 187,000 t in 2012, which is comparable to the beginning of the time series.
- Recruitment prospects are uncertain.
- Annual total mortality among age 4+ shrimp from RV surveys increased from approximately 34 % to 58 % since 2001. In the long term, the exploitation rate index has varied around 15 %. The exploitation rate decreased from 2004/2005 to 2009/2010 and increased in the following two years.
- Research survey SSB was assessed to be in the Cautious Zone, within the Integrated Fisheries Management Plan (IFMP) Precautionary Approach (PA) Framework, for the third time in the four most recent years. The 2012/2013 exploitation rate is expected to be about 15 %. If the 60,245 t Total Allowable Catch (TAC) is maintained through 2013/2014 and taken the exploitation rate will increase to 19 %; the third highest level in the time series.

SFA 5 (Hopedale and Cartwright Channels)

- Catches increased from about 15,000 t during 1997–2002 to around 23,000 t in more recent years.
- Catch per unit effort increased from 1992 to 2001 and has oscillated around this higher level since then.
- Fishable biomass index increased from around 90,000 t in 1996–99 to 184,000 t in 2001. The index has been around 150,000 t from 2004 onward. The 2012 estimate is 147,000 t.
- Female SSB index increased from 40,000 t in the 1996–99 period to 96,000 t in 2001 and has since decreased. The 2012 estimate is 63,000 t.
- Recruitment prospects are uncertain.
- Annual female total mortality oscillated between about 35–75 % over the period 1998–2011 averaging about 60 %.
- Exploitation rate has varied without trend around 15 % over most of the time series.
- Research survey SSB was assessed to be in the Healthy Zone within the IFMP PA Framework. The 2012/2013 exploitation rate is expected to be about 16 %. If the 23,300 t TAC is maintained through 2013/2014 and taken then the exploitation rate will remain at 16 %.

SFA 4 (NAFO Division 2G)

- Catches increased from approximately 10,000 t over the period 2005/2006 to 2011/2012 to approximately 13,000 t in 2012/2013.
- Fishable biomass index increased from 62,000 t in 2005 to 180,000 t by 2009, decreased to 127,000 t in the next year before increasing to 191,000 t in 2012. Similarly, the female SSB index increased from 35,000 t in 2005 to 140,000 t by 2009, decreased to 71,000 t in 2010 then increased to 110,000 t in 2012.
- Recruitment prospects are uncertain.
- Annual female total mortality oscillated between about 40–50 % over the period 1999–2008. There are no estimates available since then.
- Exploitation rate has been between 6 and 9 % since 2007/2008 and the current estimate is 7 %.
- Research survey SSB was assessed to be in the Healthy Zone, within the IFMP PA Framework, and it is anticipated that the 2012/2013 exploitation rate will be less than 10 %.

BACKGROUND

Species Biology

Northern or Pink Shrimp (*Pandalus borealis*) are found in the Northwest Atlantic from Davis Strait to the Gulf of Maine, usually in areas where the ocean floor is soft and muddy and where temperatures near the bottom range from about 1 °C to 6 °C. These conditions occur throughout the Newfoundland and Labrador offshore area within a depth range of roughly 150–600 m, thus

providing a vast area of suitable habitat. The species is the primary cold-water shrimp resource in the North Atlantic.

These shrimp are protandrous hermaphrodites. They first mature as males, mate as males for one to several years and then change sex to spend the rest of their lives as mature females. They are known to live for more than eight years in some areas. Some northern populations exhibit slower rates of growth and maturation but greater longevity results in larger maximum size.

Shrimp are thought to begin to recruit to the fishery at age three. Most of the fishable biomass is female.

During the daytime, Northern Shrimp rest and feed on or near the ocean floor. At night, substantial numbers migrate vertically into the water column, feeding on zooplankton. They are important prey for many species such as Atlantic Cod (*Gadus morhua*), Greenland Halibut (*Reinhardtius hippoglossoides*), skates, wolffish (*Anarhichas* sp.), Snow Crab (*Chionoecetes opilio*), and Harp Seals (*Phoca groenlandica*).

Fishery

The fishery for Northern Shrimp off the coast of Labrador began in the mid-1970s, primarily in the Hopedale and Cartwright (SFA 5) channels (Fig. 1). Annual catches (Fig. 2) increased steadily from less than 2,700 t in 1977 to about 4,100 t in 1981 but subsequently declined to 1,000 t in 1983 and 1984 due to poor markets and high operating costs. Economic conditions improved thereafter, and catches from SFAs 5 and 6 increased to about 7,800 t in 1987. In 1988, fishing effort became more widespread as vessels ventured into Div. 2G (SFA 4) where both catch rate and size of shrimp proved to be very attractive to the industry. Additional commercial concentrations of shrimp were located within SFA 6 in a small area east of St. Anthony Basin and in the Funk Island Deep. Catches in both 1988 and 1989 approached 17,000 t and remained in the 14,000-20,000 t range from 1990 to 1993. Exploratory fisheries along the slope of the shelf in SFAs 4, 5, and 6 in 1992 and 1993 revealed commercial concentrations of shrimp in those areas, as well.

Catches from 1994 to 1996 averaged 23,000 t increasing to 85,000 t by 2000, following increases in TAC within SFA 6 where the resource was considered to be healthy and exploitation low. The increases after 1996 were primarily reserved for the development of a small vessel (< 100 ft.) fleet which has since grown to include more than 300 vessels.

The overall TAC increased by 25,000 t in 2003. During that year industry was granted a change in management year from calendar (January 1–December 31) to fiscal (April 1–March 31). To facilitate this change, an additional 20,229 t interim quota was allocated to the large vessel fleet and the 2003/2004 management period became 15 months in length. The 2004/2005 management year was 12 months in duration and total allocations equaled 111,552 t. This TAC was maintained until 2008-09 when it was increased to 120,344 t. This TAC was maintained through to 2009/2010; however, due to operational and commercial constraints, it was not taken. Under the IFMP PA framework, the SFA 6 TAC was decreased by 28 % to 61,632 t resulting in an overall TAC of 96,252 t for the 2010/2011 management year. Resource status declined further in 2010/2011 therefore the SFA 6 TAC was reduced by 15 % to 52,387 t resulting in an overall TAC of 87,007 t for the 2011/2012 management year. Resource status in SFA 6 improved in 2011, therefore, the 2012/2013 SFA 6 TAC was increased to 60,245 t; resource indices remained high in SFA 4 therefore the TAC in SFA 4 was increased to 13,018 t resulting in an overall SFAs 4-6 TAC of 96,563 t for the 2012/2013 management year. It was anticipated that this TAC will be taken by March 31, 2013.

During 2007 a seasonal bridging program was established that allows each license holder to fish up to 750 t of unused quota from the previous year or take it from the next year's quota.

All Northern Shrimp fisheries in eastern Canada are subject to the Atlantic Fisheries Regulations regarding territorial waters, by-catches, discarding, vessel logs, etc. These include a minimum mesh size of 40 mm and mandatory use of sorting grates to minimize by-catch of non-target species. Grate size is dependent upon area fished and vessel class. Observers are required on all trips by the large vessel fleet and a target of 10 % coverage has been established for the small vessel fleet though this target is rarely achieved.



Figure 2. Historical Northern Shrimp catches (SFAs 4-6) and TACs for the period 1977-2012 (2012/2013 catches are preliminary). In 2003, the management year changed to a fiscal year.

ASSESSMENT

Resource status was evaluated based on trends in fishery CPUE derived from logbooks and observer datasets, indices from DFO fall multi-species bottom trawl surveys in Div. 2HJ3K, a joint NSRF-DFO summer shrimp-based survey in Div. 2G, as well as biological sampling from multiple sources.

The bottom trawl surveys provide indices of total abundance, SSB, fishable biomass, and total biomass. Indices include the abundance of shrimp with 11.5-17 mm carapace lengths and the abundance of age 2 animals based on modal analysis. The fishable biomass is defined as the weight of all males and females with a carapace length > 17 mm. Exploitation rate index was determined by comparing the catch to the survey fishable biomass index (catch/previous year fall fishable biomass index for SFAs 5 and 6; catch/current year summer fishable biomass index for SFA 4). Total mortality was based on the RV survey abundance of age 5+ in year $t + 1$ divided by abundance of age 4+ in year t , averaged over four years. Annual female total mortality based on observer data was calculated as the abundance of multiparous females in year $t + 1$ divided by abundance of all females in year t .

The PA framework was applied using an Upper Stock Reference (USR = 80 % of the geometric mean of SSB over a productive period) and a Limit Reference Point (LRP = 30 % of the geometric mean of SSB over a productive period) superimposed upon the exploitation rate trajectory over time. Due to differences in survey history, the respective productive time periods were thought to be 1996–2003 for SFA 6, 1996–2001 for SFA 5, and 2005–09 for SFA 4.

SFA 6 (Hawke Channel and NAFO Division 3K)

Commercial Fishery:

The TAC was set at 11,050 t in 1994 and increased to 23,125 t in 1997 (Fig. 3) as a first step towards increasing the exploitation of an abundant resource. Most of the increase was reserved for development of the small vessel fleet. The TAC more than doubled between 1997 and 1999, increased to 61,632 t in 2002 and then to 77,932 t in 2003. An additional interim quota of 7,653 t was set for the fishing season January 1–March 31, 2004 to facilitate an industry requested change in fishing season from April 1 to March 31. Thus the 2003/2004 management period was 15 months long and had an 85,585 t TAC. The 2004/2005 management year was 12 months and had a 77,932 t TAC. As a result of the seasonal bridging program, the 77,932 t TAC for 2007/2008 was increased by 2,000 t. The TAC was increased to 85,725 t in 2008/2009 and maintained through 2009/2010. Due to operational factors/market conditions, the TAC was not taken during either of these years. The 2010/2011 TAC was reduced to 61,632 t and further to 52,387 t in 2011/2012. Resource status improved during 2011 and subsequently the TAC was increased to 60,245 t in 2012/2013. It is anticipated that the TAC will be taken.

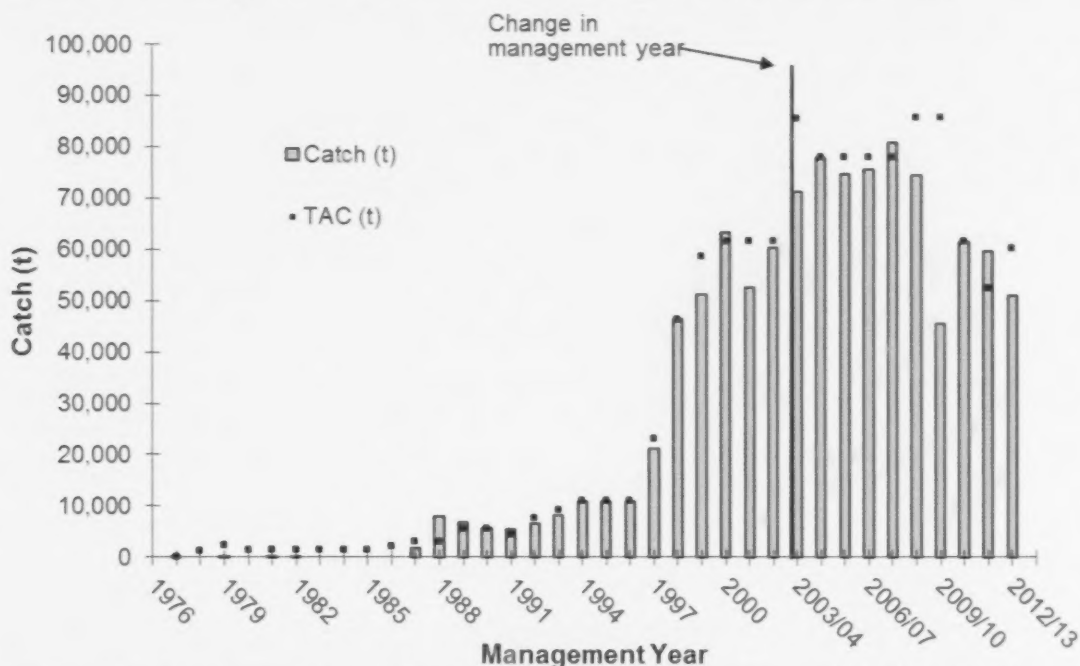


Figure 3. Historical Northern Shrimp catches (SFA 6) and TACs for the period 1977-2012 (2012/2013 catches are preliminary). In 2003, the management year changed to a fiscal year.

The large vessel CPUE increased between 1989 and 1997 and oscillated at a high level until 2006/2007, thereafter it declined until 2009/2010 but has since been increasing. The small vessel CPUE showed a similar pattern (Fig. 4).



Figure 4. SFA 6 large and small vessel standardized CPUE (error bars indicate 95% confidence intervals).

Biomass

Fishable biomass index increased from 310,000 t in 1997 to a peak of nearly 670,000 t in 2006 then declined steeply to 295,000 t in 2010, increased to 409,000 t in 2011 before returning to 316,000 t by 2012. The trend in female spawning stock biomass index reflected the trend in the fishable biomass index decreasing to 187,000 t in 2012, which is comparable to the beginning of the time series (Fig. 5).

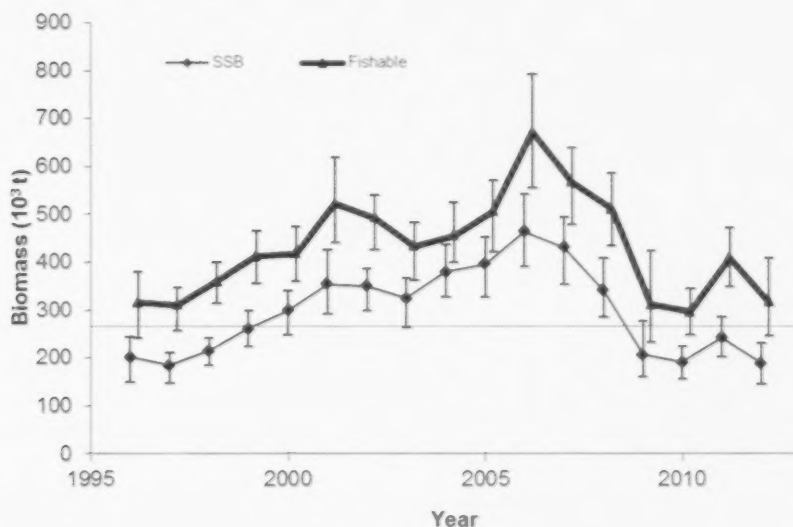


Figure 5. SFA 6 biomass indices (error bars indicate 95% confidence intervals). The dotted line is the geometric mean of SSB over the years 1996-2003 and is used as a proxy for B_{MSY} .

Recruitment

Recruitment prospects are uncertain because there is no apparent relationship between available indices (Fig. 6) and subsequent SSB (Fig. 5). For example, the expected lag between changes in SSB and recruitment at age 2 is not apparent, but instead recruitment indices and SSB trend together.

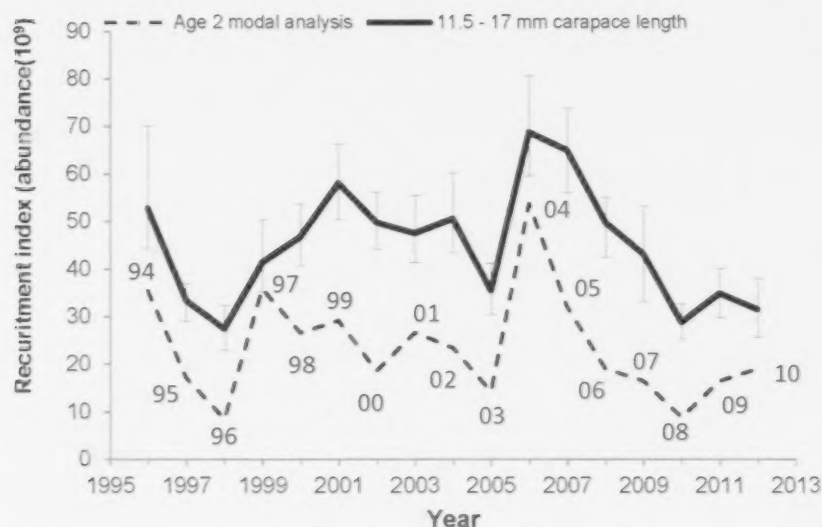


Figure 6. SFA 6 recruitment indices (error bars indicate 95% confidence intervals). Numbers denote year classes derived from modal analysis.

Mortality

Annual total mortality among age 4+ shrimp from RV surveys increased from approximately 34-58 % since 2001 (Fig. 7).

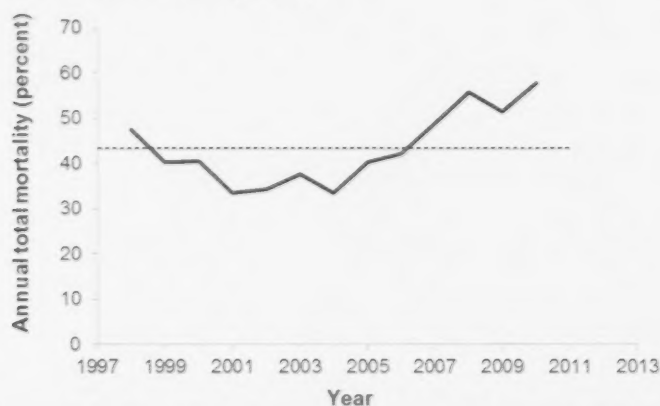


Figure 7. Total mortality index based on the RV survey abundance of age 5+ in year $t + 1$ divided by abundance of age 4+ in year t , averaged over four years. Year is the third year of the four year period. The dotted line is the average over the time series.

In the long term, the exploitation rate index has varied around 15 %. The exploitation rate decreased from 2004/2005 to 2009/2010 and increased in the following two years (Fig. 8).

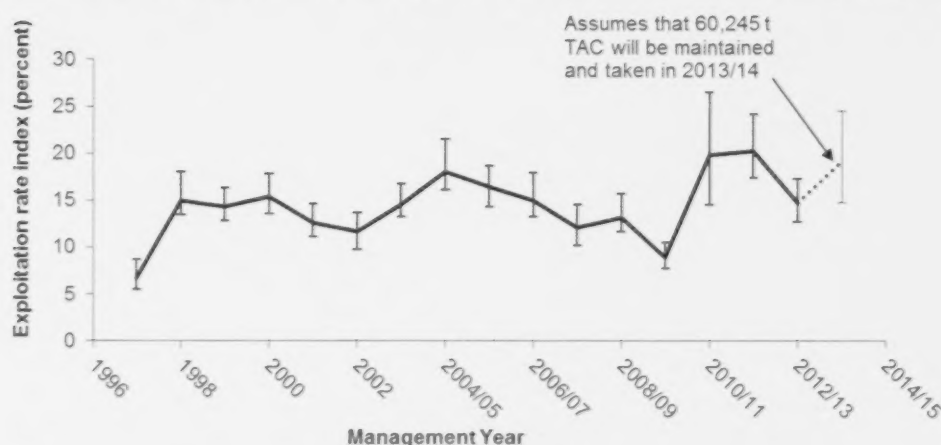


Figure 8. SFA 6 exploitation rate index based on the total catch/fishable biomass index from the previous year, expressed as a percentage. Error bars indicate 95% confidence intervals. The 2012/2013 fishery was ongoing therefore the catch was set equal to the TAC.

Current Outlook and Prospects

Research survey SSB was assessed to be in the Cautious Zone, within the IFMP PA Framework, for the third time in the four most recent years. The 2012/2013 exploitation rate is expected to be about 15 %. If the 60,245 t TAC is maintained through 2013/2014 and taken the exploitation rate will increase to 19 %; the third highest level in the time series (Fig 9).

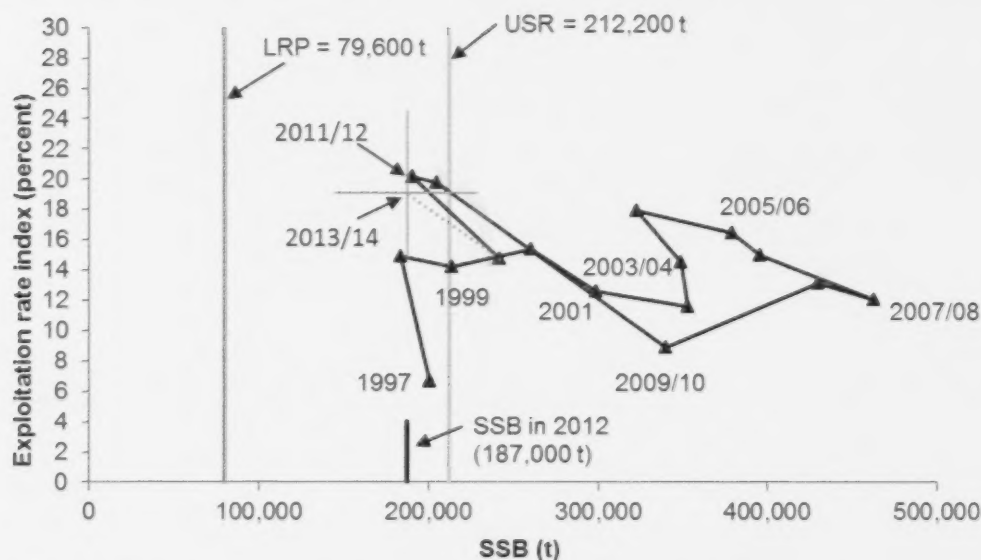


Figure 9. SFA 6 Precautionary Approach framework with trajectory of exploitation rate index vs. SSB. Numbers denote management year. The 2012/2013 fishery was ongoing therefore the catch was set equal to the TAC. The red cross indicates the 95% confidence interval for the fall 2012 SSB (horizontal bar), and the exploitation rate if the 2012/2013 TAC of 60,245 t is maintained (vertical bar) through 2013/2014.

SFA 5 (Hopedale and Cartwright Channels)

Commercial Fishery

The TAC doubled from 7,650 t during 1994-96 to 15,300 t over the 1997-2002 period. In 2003, the TAC increased to 23,300 t, the management year changed to April 1–March 31, and an additional interim quota of 9,787 t was set for the period January 1–March 31, 2004. Thus the 2003/2004 management period was 15 months long and had a 33,087 t TAC. The 2003/2004 TAC (23,300 t) was maintained through to 2012/2013. The TAC has been taken in most years. As a result of the seasonal bridging program, the 23,300 t TAC for 2009/2010 and 2011/2012 was allowed to be exceeded by 2,000 t in each of these years. Approximately 18,000 t were taken by January 28, 2013 and it is anticipated that the remainder of the TAC will be taken (Fig. 10).

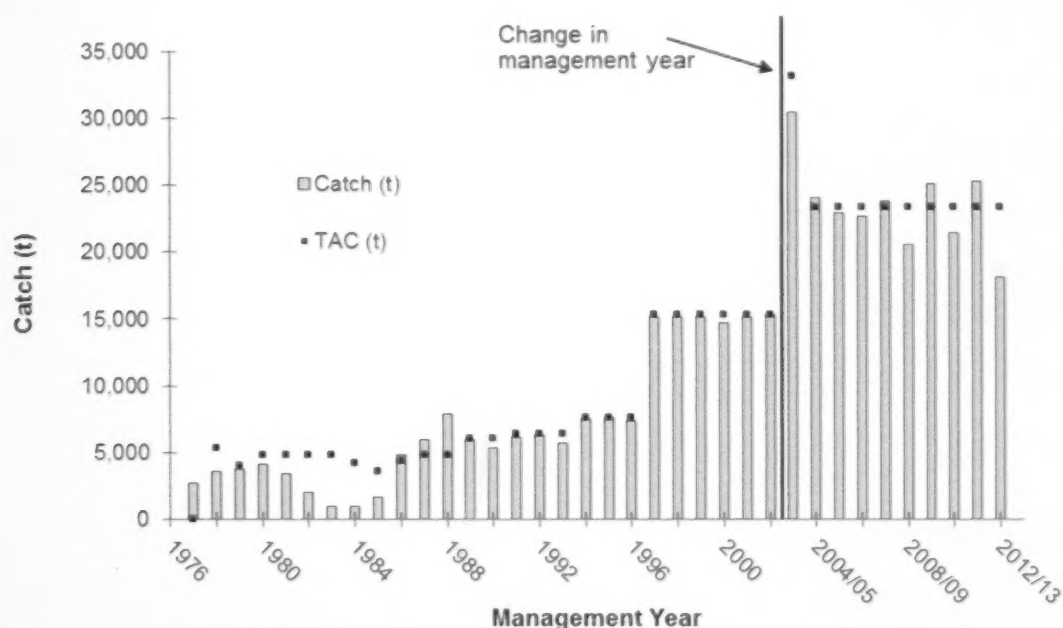


Figure 10. SFA 5 historical Northern Shrimp catches and TACs for the period 1977-2012/2013 (2012/2013 catches are preliminary). In 2003, the management year changed to a fiscal year.

CPUE increased from 1992 to 2001 and has oscillated around this higher level since then (Fig. 11).

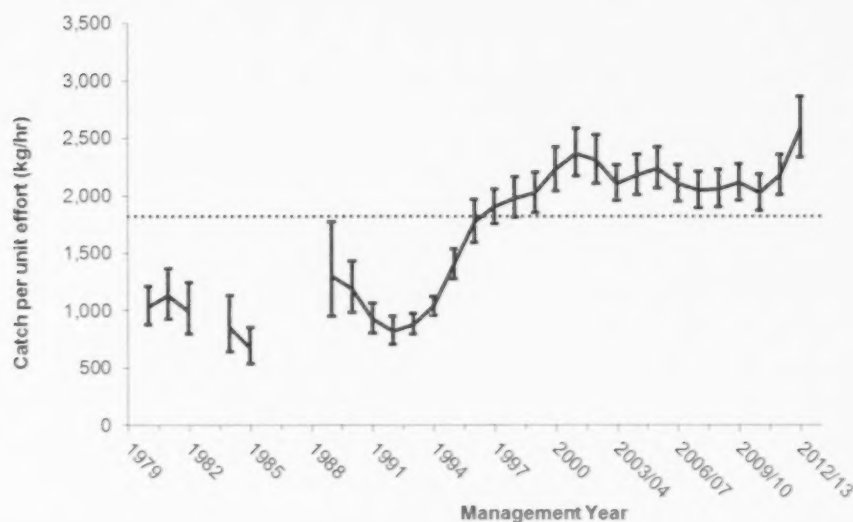


Figure 11. SFA 5 large vessel standardized CPUE (error bars indicate 95% confidence intervals). The dotted line is the average over the time series.

Biomass

Fishable biomass index increased from around 90,000 t in 1996-99 to 184,000 t in 2001. The index has been around 150,000 t from 2004 onward. The 2012 estimate is 147,000 t (Fig 12).

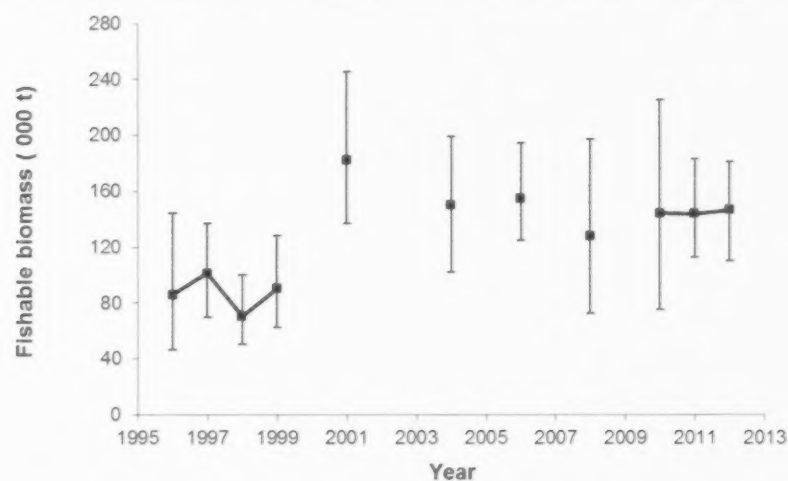


Figure 12. SFA 5: fishable biomass index within the entire of SFA 5 (error bars indicate 95% confidence intervals).

Female spawning stock index increased from 40,000 t in the 1996-99 period to 96,000 t in 2001 and has since decreased. The 2012 estimate is 63,000 t (Fig. 13).

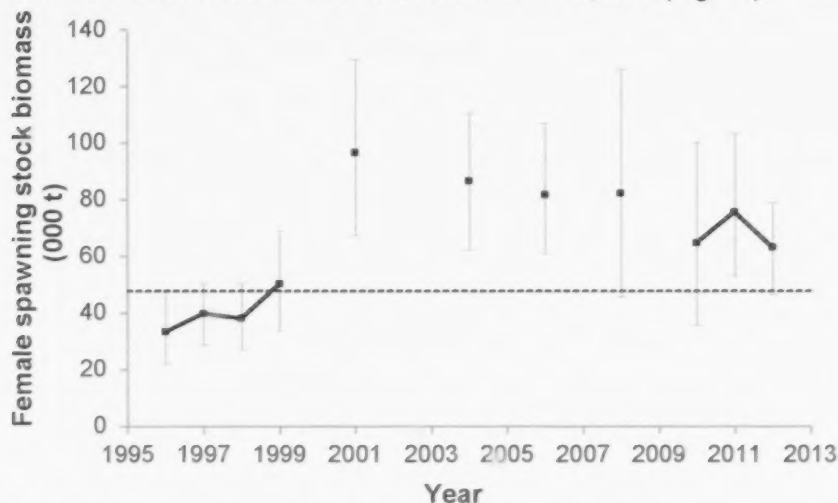


Figure 13. SFA 5 SSB index (error bars indicate 95% confidence intervals). The dotted line is the geometric mean over the years 1996-2001 and is used as a proxy for B_{MSY} .

Recruitment

Recruitment prospects are uncertain because there is no apparent relationship between available indices (Fig. 14) and subsequent SSB (Fig. 13).

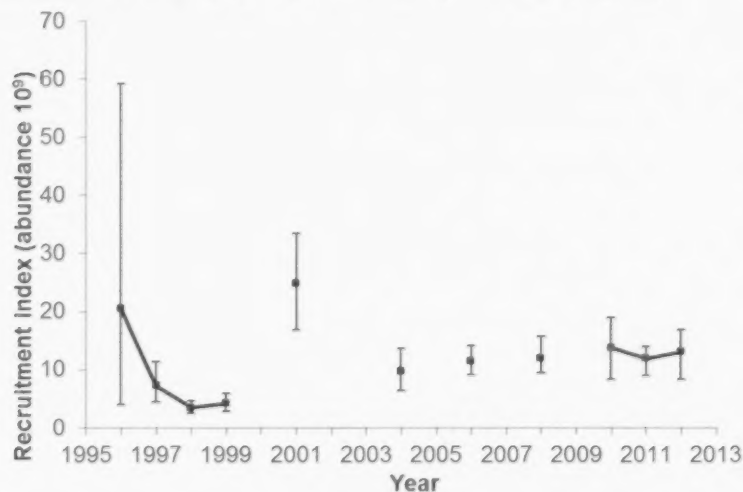


Figure 14. SFA 5 recruitment index (11.5 – 17 mm carapace length shrimp of both sexes; error bars indicate 95% confidence intervals).

Mortality

Annual female total mortality oscillated between about 35-75 % over the period 1998–2011 averaging about 60 % (Fig 15).

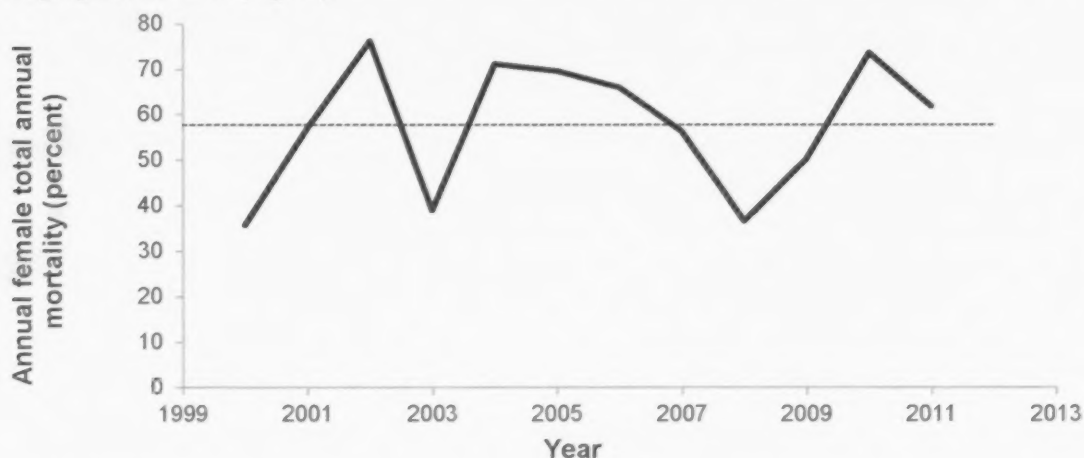


Figure 15. Female total mortality index based on the observed commercial abundance of multiparous females in year $t + 1$ divided by abundance of all females in year t , averaged over four years. Year is the third year of the four year period. The dotted line is the average over the time series.

Exploitation rate has varied without trend around 15 % over most of the time series (Fig. 16).

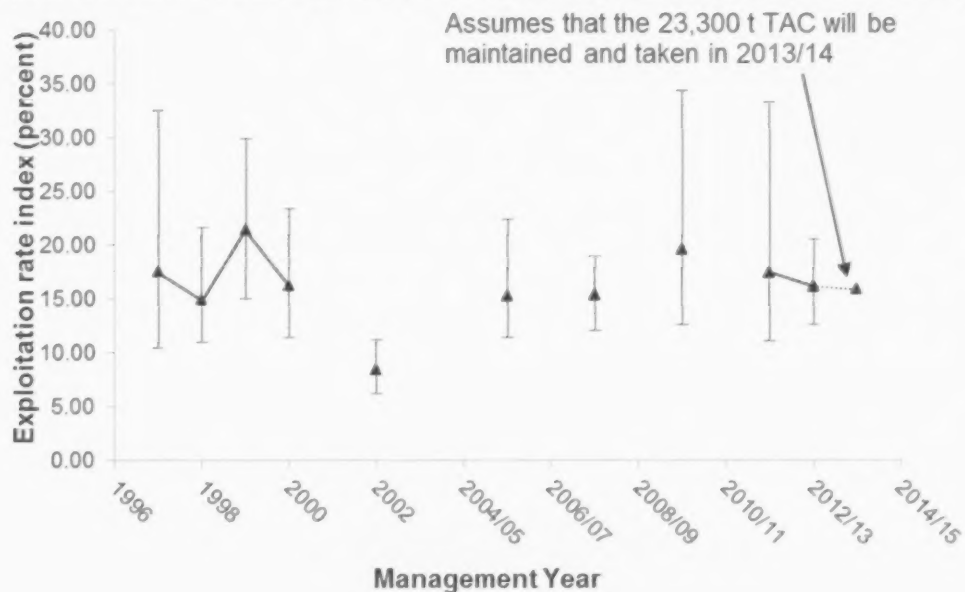


Figure 16. SFA 5 exploitation rate index over the period 1996–2012/2013 (error bars indicate 95% confidence intervals).

Current Outlook and Prospects

Research survey SSB was assessed to be in the Healthy Zone within the IFMP PA Framework. The 2012/2013 exploitation rate is expected to be about 16 %. If the 23,300 t TAC is maintained through 2013/2014 and taken then the exploitation rate will remain at 16 % (Fig. 17).

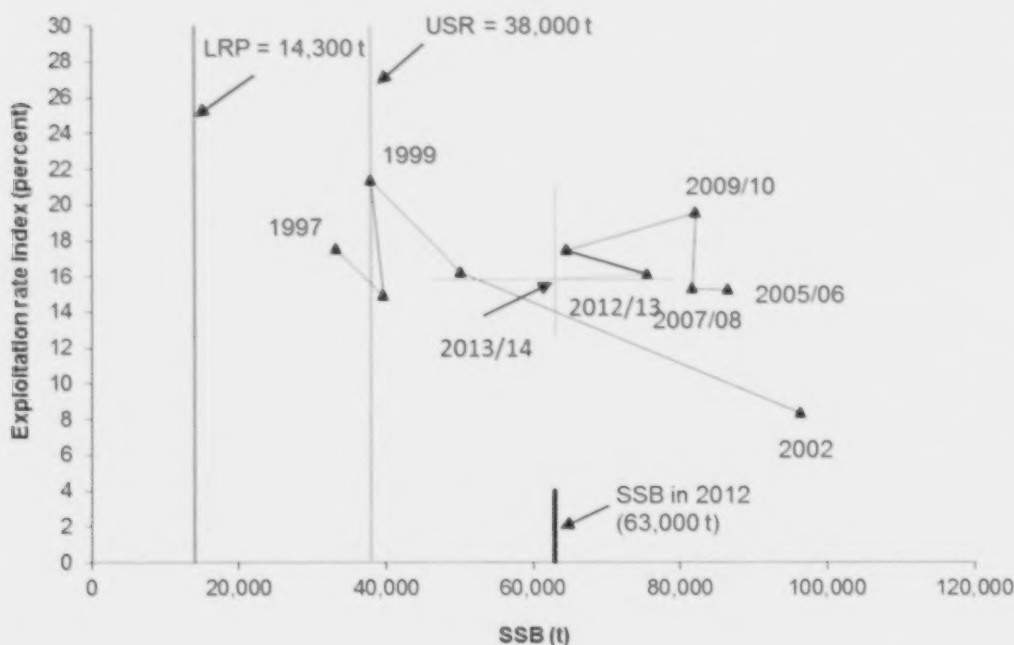


Figure 17. Numbers denote management year. The red cross indicates the 95% confidence interval for the fall 2012 SSB (horizontal bar), and the exploitation rate if the 2012/2013 TAC of 23,300 t is maintained (vertical bar) through 2013/2014.

SFA 4 (NAFO Division 2G)

Commercial Fishery

The TAC increased from 2,580 t in 1989 to 5,200 t in 1995 and 8,320 t in 1998 (Fig. 18). In 1998, 2,184 t of the TAC was allocated to the area south of 60°N to promote spatial expansion of the fishery. The 2003 TAC was increased to 10,320 t. In 2003 the management year changed to April 1–March 31, and an additional interim quota of 2,802 t was set for the period January 1–March 31, 2004. Thus the 2003/2004 management period was 15 months and had a 13,122 t TAC. The 10,320 t TAC was maintained through to 2007/2008. By 2009/2010, the regulations were changed such that the vessels no longer had to fish a portion of their catch in southern SFA 4. The TAC was set at 11,320 t for the 2008/2009 to 2010/2011 management years and increased to 13,018 t in 2012/2013. Preliminary data indicate that approximately 13,000 t were taken during the 2012/2013 management year.

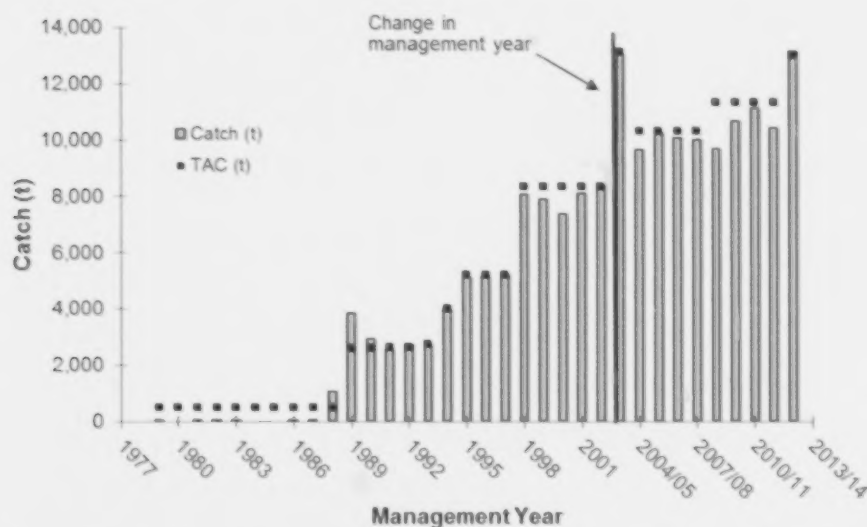


Figure 18. SFA 4 historical Northern Shrimp catches and TAC for the period 1979-2012/2013 (2012/2013 catches are preliminary).

Several factors including changes in management measures and species composition of catches confound the interpretation of fishery performance in this area, therefore, no CPUE model is provided.

Biomass

Fishable biomass index increased from 62,000 t in 2005 to 180,000 t by 2009, decreased to 127,000 t in the next year before increasing to 191,000 t in 2012. Similarly, the female SSB index increased from 35,000 t in 2005 to 140,000 t by 2009, decreased to 71,000 t in 2010 then increased to 110,000 t in 2012 (Fig. 19).

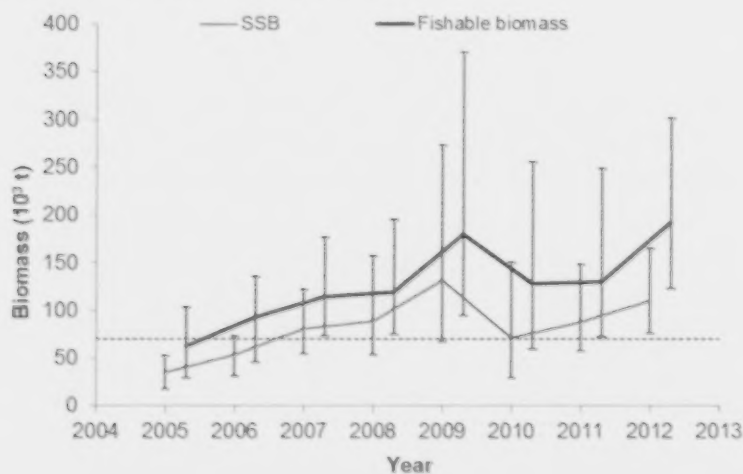


Figure 19. SFA 4 biomass indices (error bars indicate 95% confidence intervals). The dotted line is the geometric mean of SSB over the years 2005-2009 and is used as a proxy for B_{MSY} .

Recruitment

Recruitment prospects are uncertain because there is no apparent relationship between available indices (Fig. 20) and subsequent SSB (Fig. 19).

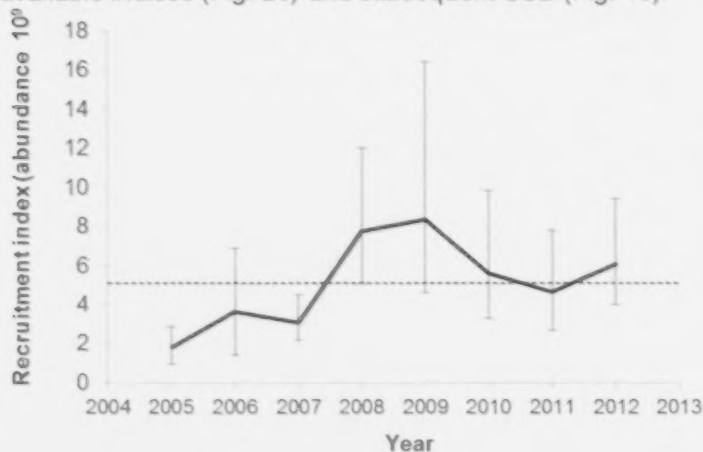


Figure 20. SFA 4 recruitment index (error bars indicate 95% confidence intervals). The dotted line is the average over the time series.

Mortality

Annual female total mortality oscillated between about 40-50 % over the period 1999–2008 (Fig. 21). There are no estimates available since then due to high proportion of ovigerous females in the commercial catch.

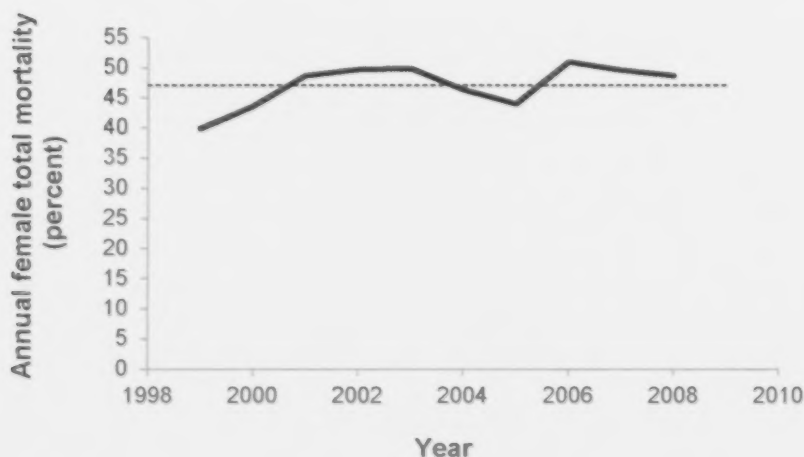


Figure 21. Annual female total mortality index based on the observed commercial abundance of multiparous females in year $t + 1$ divided by abundance of all females in year t , averaged over four years. Year is the third year of the four year period. The dotted line is the average over the time series.

Exploitation rate has been between 6 and 9 % since 2007/2008 and the current estimate is 7 % (Fig. 22).

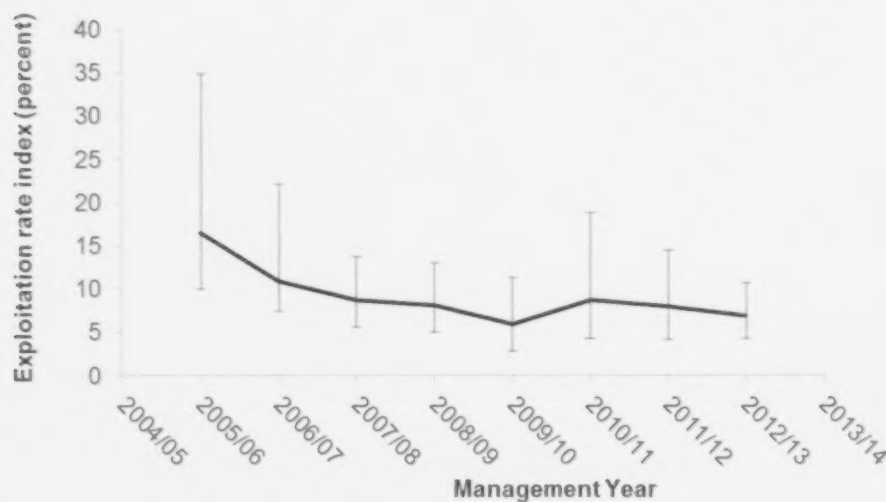


Figure 22. SFA 4 exploitation rate index. (total catch/fishable biomass index from the same year; error bars indicate 95% confidence intervals).

Current Outlook and Prospects

Research survey SSB index was assessed to be in the Healthy Zone, within the IFMP PA Framework, and it is anticipated that the 2012/2013 exploitation rate will be less than 10 % (Fig. 23) once catch reporting is complete.

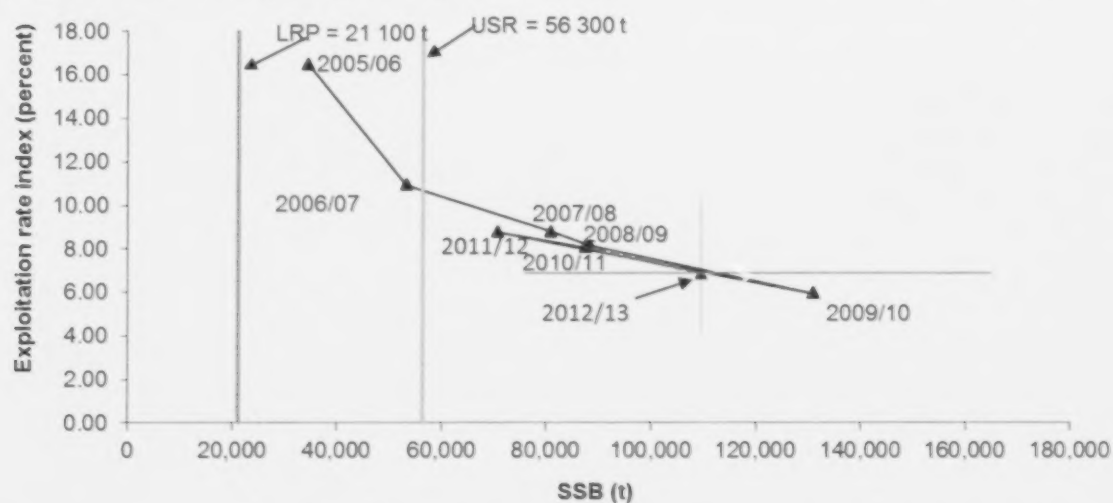


Figure 23. Precautionary Approach framework with trajectory of exploitation rate index vs SSB. Numbers denote management year. The red cross indicates the 95% confidence interval for the summer 2012 SSB (horizontal bar), and the exploitation rate for 2012/2013 (vertical bar).

Sources of Uncertainty

SFA 4-6

The implications of finishing some fall DFO multi-species surveys later than usual, in SFAs 5 and 6, are unknown.

Spatio-temporal variation among three DFO research vessels particularly in NAFO Div. 3K (SFA 6) is a source of uncertainty and the implications are unknown.

The survey in SFA 4 had been conducted by the *Cape Ballard* from 2005 to 2011. In 2012, the *Aqviq* was used after the *Cape Ballard* became unserviceable. Following the survey it was determined that the survey protocol was not followed in that the warp ratio was shortened. No inter-calibration was conducted. These changes may have affected trawl performance and it is unknown what effect they had on the survey results.

The shortness of the survey time series, lack of dynamic range and stock-recruit relationships limits modeling stock dynamics. There is no risk analysis for this resource. There is uncertainty in the appropriateness of the current reference points as it is unknown how the survey biomass relates to BMSY.

The current management areas may not represent biological units. Causes in one management area may produce effects in other management areas.

Trawls used in the surveys have shrimp catchability less than one but the exact value is unknown. Therefore, the survey underestimates biomass. Catch is known; however, the total fishery-induced mortality is unknown (landed catch plus incidental mortality from trawling). Exploitation rates are a relative index rather than absolute.

Physical changes in the environment may affect the availability of shrimp to commercial and survey trawls.

CONCLUSIONS AND ADVICE

SFA 6

There is concern for the current status. The trend in female SSB index reflected the trend in the fishable biomass index decreasing to 187,000 t in 2012, which is comparable to the beginning of the time series. The SSB is in the Cautious Zone of the IFMP PA framework for the third time in the four most recent years.

Total annual mortality increased from 34 % to 58 % after 2001. If the 60,245 t TAC is maintained through 2013/2014 and taken the exploitation rate will increase to 19 %, the third highest level in the time series.

SFA 5

Current status remains positive. Fishable biomass index increased from around 90,000 t in 1996-99 to 184,000 t in 2001. The index has been around 150,000 t from 2004 onward. The 2012 estimate is 147,000 t. SSB index increased from 40,000 t in the 1996-99 period to 96,000 t in 2001 and has since decreased. The 2012 estimate is 63,000 t. SSB is in the Healthy Zone of the IFMP PA framework and if the current TAC is taken in 2013/2014, the exploitation rate index would remain at 16 %.

SFA 4

Current status remains positive. Biomass indices are at or near their highest levels over the short time series. The exploitation rate has been between 6 % and 9 % since 2006/2007. SSB index was assessed to be in the Healthy Zone, within the IFMP PA Framework, and it is anticipated that the 2012/2013 exploitation rate will be less than 10 %.

OTHER CONSIDERATIONS

Environment and Ecosystem Considerations for Northern Shrimp stocks

Since the mid-1990s, there has been a strong trend toward warmer ocean conditions in the Northwest Atlantic, and climate model forecasts support a continuation of this warming into the next decade. Despite this increase in recent years, there was more winter cooling of the water column in northern areas during 2012, resulting in a significant decrease in ocean temperatures compared to record highs in 2011. However, conditions in 2012 were generally warmer than average.

The area of the bottom covered by water in the 2-4 °C range in the Div. 2J3K region decreased in 2012 compared to the previous 2 years. Analyses show that 84 % of fishable catch of shrimp during the fall surveys are associated with this relatively warm Labrador slope water. Both the CPUE and fishable biomass were shown to be positively correlated with temperature indices and negatively correlated with sea ice, cold intermediate layer (CIL) and the North Atlantic Oscillation (NAO) index. Positive correlations between temperature indices with the fishable biomass/CPUE and the timing of the annual production cycle indicate an effect on early life stages of shrimp in some areas.

Indices of primary and secondary production have remained relatively stable over the past decade and in some cases have trended upwards (e.g., copepod abundance), which may support feeding of early life stages (larval and juvenile) along with adult Northern Shrimp. The peak timing of the spring bloom based on satellite imagery is generally advancing in recent years and is shorter in duration which may influence the temporal availability of prey to secondary producers and higher trophic levels.

During the late 1980s and early 1990s most of the fish community in the Newfoundland and Labrador marine ecosystem collapsed; during this time shrimp biomass increased significantly. In more recent years (~2004-07) some fish species increased from their very low level in the mid-1990s; but most increases have stalled after 2007. Current levels are still well below pre-collapse ones.

In the mid-1990s, shrimp became an important prey for several key groundfish species. However, shrimp dominance in the diets seems to be in decline, tracking the relative availability of shrimp in the ecosystem. In 2011, there was a decrease in the contribution of shrimp to the diet of Atlantic Cod, Greenland Halibut, and American Plaice (*Hippoglossoides platessoides*). The reduction of shrimp in the diet seems to be more important in the southern areas. Despite these changes, shrimp continues to be an important forage species.

Considerations for Management

Exploitation strategies for this resource should take into consideration the importance of shrimp as a forage species. Shrimp and Capelin are key forage species in NAFO Div. 2J3KL (SFAs 5,

6 and 7). Capelin abundance is at very low levels while some groundfish are increasing. Together this may increase predation pressure on shrimp.

The current IFMP recognizes that shrimp is a key forage species and therefore shrimp management has adopted a more conservative approach than what would otherwise be adopted under a single species management approach. There is consensus that there is need for better understanding of ecosystem demands on shrimp as a forage species and to incorporate this improved understanding into shrimp harvesting strategies in future assessments. In this context there is a need for focused research on how these linkages should be reflected in the setting of reference points.

Effects of climate change on shrimp resources should be considered when making management decisions. However, the meeting agreed that there is a need to conduct more research to determine whether environmental variables could be used in conjunction with recruitment signals to produce resource status predictions. For example, once the fishable biomass and commercial fishing performance have been lagged by four years, positive correlations have been found with temperature indices and the timing of the annual phytoplankton production cycle, indicating that these environmental variables have an impact upon the early life stages in some areas. It is worth noting that the thermal regime has been warming over the past decade peaking in 2011, before cooling significantly in 2012.

SOURCES OF INFORMATION

This Science Advisory Report is from the zonal advisory process meeting held 18-26 February 2012 on the assessment of Northern and Striped Shrimp in SFAs 2-6. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2007. Assessment framework for Northern Shrimp (*Pandalus borealis*) off Labrador and the northeastern coast of Newfoundland; 28-30 May 2007. DFO. Can. Sci. Advis. Sec. Proc. Ser. 2007/034.

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